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CONDITIONING CHILDREN FOR SCHOOL. FINAL REPORT.

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A SET OF BEHAVIORAL PRINCIPLES USED IN INTELLECTUAL REHABILITATION OF A SMALL GROUP OF THIRD GRADERS WITH EDUCATIONAL AND RELATED BEHAVIORAL PROBLEMS WAS EVALUATED. SUBJECTS SELECTED WERE EIGHT THIRD-GRADE STUDENTS AGED 8 TO 10, WHO WERE 1 YEAR BEHIND IN READING AS MEASURED BY A STANDARDIZED ACHIEVEMENT TEST AND 1 YEAR BEHIND IN EITHER SPELLING OR MATHEMATICS AS MEASURED BY THE SAME TEST. THEIR VISION AND HEARING WERE ESSENTIALLY NORMAL. SUBJECTS PARTICIPATED FOR 8 WEEKS IN BOTH EXPERIMENTAL AND CONTROL CONDITIONS BY WORKING IN MATCHED PAIRS IN EITHER CONDITION IN ONE OR TWO AREAS. IN ALL THREE AREAS, THE PROCEDURES INVOLVED A PRETRAINING PERIOD WITH EASY REWARDS AND A MORE DIFFICULT TRAINING PERIOD. AT FIRST, REINFORCEMENT WAS KEPT IN VIEW, GIVEN IMMEDIATELY, AND USED TO DIFFERENTIATE THE EXPERIMENTER FROM OTHER ADULTS WITH WHOM THE STUDENTS HAD HAD UNFORTUNATE EXPERIENCES. CORRECTION AND EXPLANATION WERE GIVEN. THE MATERIALS WERE PROGRAMED ON MATCH-TO-SAMPLE SLIDES, AND THE CHILDREN RESPONDED BY PUSHING THE APPROPRIATE BUTTON. IN THE 5TH, 6TH, OR 7TH WEEK, THE REWARDS WERE CHANGED FROM MONETARY TO SOCIAL ONES. THE REWARD SCHEDULE AND SPEED OF PRESENTATION WERE ALSO MANIPULATED. MATERIAL WAS KEPT (ESPECIALLY IN THE INITIAL STAGES) AT A LEVEL NEITHER TOO DIFFICULT NOR TOO EASY. IN THE MATHEMATICS PROGRAM, STUDENTS WERE GIVEN BOTH A DIFFICULT AND MIXED-DIFFICULTY SERIES. READING AND SPELLING TRAINING WERE WITH 2,021 WORDS FROM THORNDIKE WORD LIST. MATHEMATICS TRAINING, BECAUSE OF THE UNEXPECTEDLY FAST LEARNING RATE, WAS CHANGED FROM 2,000 TO 4,000 PROBLEMS. OF THREE SOMATIC MEASURES TAKEN THROUGHOUT TRAINING, ONLY TEMPERATURE WAS OBSERVED TO HAVE AN EFFECT UPON PERFORMANCE. RESULTS INDICATED THAT EXPERIMENTAL STUDENTS GENERALLY IMPROVED MORE THAN DID THE CONTROLS. GRADE CHANGES WERE NOTED IN ALL AREAS (BEST IN SPELLING) FOR THE EXPERIMENTAL SUBJECTS, AND TEACHER RATINGS WERE HIGHER FOR THEM (SIGNIFICANT AT THE .014 LEVEL ONLY IN SPELLING). LEARNING DID NOT APPEAR TO BE MARKEDLY AFFECTED BY CHANGES IN TYPE OR SCHEDULE OF REINFORCEMENT. POSTTESTS AFTER 4 MONTHS REVEALED RETENTION BEST IN MATHEMATICS. APPENDIXES CONTAIN THE PRETRAINING MATHEMATICS SEQUENCE, A LIST OF WORDS WITH SEMANTIC ASSOCIATION INDEX, AND A SAMPLE OF PROGRAMED SPELLING WORDS. (JD)

FINAL REPORT

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Conditioning Children for School

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Introduction

This is the final report of a study designed to evaluate a set of behavioral principles used in the intellectual rehabilitation of a small group of third graders with educational and related behavioral problems. These principles were incorporated in a training program which had salutary effects on the children directly involved but also indicated that the precise manipulation of such variables as time, amount, and schedules of reinforcement can have long term beneficial effects for all categories of elementary school children. Perhaps the most important aspect of the behavioral training employed was to prepare children to compete for their share of attention and praise in classroom situations that differ markedly from the atmosphere that prevails in the learning laboratory.

The general purposes of this study can be broken down into a list of more specific goals and enumerated as follows: (1) the development of behaviors prerequisite to all types of learning such as alertness, attentiveness, and persistence; (2) the use of monetary rewards in the early stages of learning to promote a high level of performance and a gradual shift from monetary reward to the social rewards found in the classroom such as approval and praise; (3) increase student capacity to tolerate the inevitable delays between the successful completion of school work and the teacher's acknowledgment and approval of that success; (4) reduction of student antagonism to such school subjects as reading by reintroducing them in ways that permit the extinction of emotional responses that compete with effective reading; (5) enlargement of the verbal and mathematical repertoires of students to the point where they will have the confidence to participate in classroom discussions, exercises, and other activities.

Method

Subjects.

In December, 1966, eight students were selected from 120 third graders at St. Benedict Roman Catholic Parochial School, Evansville, Indiana. The criteria for the selection of students were, (1) the children had to be between the ages of eight and ten, (2) they had to be at least one year behind the reading level for third graders as measured by a recognized achievement test, (3) they had to be a year behind in one of two additional subjects (mathematics and spelling) as measured by the same achievement test. Fortunately (and in another sense unfortunately), it was easy to find eight third grade youngsters that met these criteria. Pre-experimental work with these students began in January and the formal training part of the experiment began in the middle of February.

All students were tested for near acuity, distance acuity, color vision, and depth perception on the Ortho-Rater by an experienced examiner. All students were emmetropic or wore corrective lenses and had normal color vision. Tests of depth perception are frequently unreliable with young children. To help solve this problem, the Howard-Dahlman depth perception apparatus was used in addition to the Ortho-Rater. It turned out to be an easier device for children in making judgments of depth. None of the children were seriously deficient in this visual capacity.

Audiometric test revealed no significant hearing loss for any of the children. The results of vision and audition tests are summarized in Table 1.

Experimental Design.

Several possibilities were considered for the control condition to be used in this experiment. The first idea was to simply train four of

TABLE 1

Visual and Auditory Acuity Measures on Eight Student Subjects

Student	Visual Acuity Reciprocal - Visual Angle		Color Vision	Depth Perception	Hearing Loss Over 5 db.	
	Right Eye	Left Eye	Ortho-Rater	Howard-Dahlman*	Right Ear	Left Ear
1	1.0	.80	Normal	88.5%	0	0
2	1.0	1.0	Normal	96.0%	0	0
3	.90	1.0	Normal	102.4%	0	0
4	.90	.90	Normal	88.5%	0	0
5	1.0	1.0	Normal	88.5%	0	0
6	.80	.90	Normal	96.0%	0	0
7	1.0	1.0	Normal	96.0%	0	0
8	1.1	.90	Normal	102.4%	0	0

* Per Cent Stereopsis Fry-Shepard Scale

the students and to compare their performance with four matched-pairs left untrained. This approach was rejected on the grounds that the experiment might be confounded by the novelty effect. That is, students in the experimental group might appear superior to the controls because of the novelty and excitement of participating in an experiment rather than any intrinsic value of the training employed. It would, of course, be possible to expose the control group to some of the novelty of experimentation. This method, while experimentally sound, requires that a considerable amount of time and effort be spent on a group of children without contributing to their educational growth. Further, it would be difficult, in some instances, to distinguish between activities to control for novelty effects and those considered part of the experimental training program.

Because of the limitations of the above approaches, it was decided to use the same students in both the experimental and control conditions. This was accomplished by first selecting three areas of instruction--reading, spelling, and mathematics--to be emphasized in the experimental training period. These areas were chosen because (a) grades were available in these subjects for all students back to the first grade level, (b) these are major subjects taught in succeeding grades, (c) performance changes in these areas are readily observable. For each subject area all eight students were divided into matched-pairs on the basis of scores on the Science Research Associates Achievement Series for third and fourth grades. The subtests of this test series afford separate scores for reading, spelling, and mathematics.

One student in each matched pair was randomly assigned to the experimental condition and the other to the control condition, with the restriction that each student be included in the experimental condition in

at least one subject area and that no student be in the experimental condition for more than two subject areas. Thus, all students participated in the experiment at least part of the time.

Previous work in the author's laboratory indicated there was little carry over from one subject area to another. The fact that a student was given training in mathematics did not compromise his value as a control for spelling. The likelihood of progressive error was further reduced by having each type of training occur approximately an equal number of times at each stage of practice.

A schematic of the way students were assigned is shown in Table 2. SRA Achievement levels are expressed in grade year and month in grade.

Prior to the onset of formal training, all eight students were tested on a number of educational test items. These included oddity problems, mathematical algorithms, spelling, vocabulary drawn from third grade text books, and some classical concept formation items. An illustrative sample of these items is shown in Appendix A. Performance on these pre-training test items and performance on the related items of the SRA Achievement Series Subtests ranged between .88 and .95. This is convincing evidence that the SRA Test assesses the same type of academic skills as those to be utilized in this training program and that this achievement test is a good instrument for matching intellectual abilities at this level.

Two third grade teachers, both of whom were familiar with the school performance of the eight selected students, were asked to rank the students in each of the three subject areas. The rank order correlations between these rankings and test scores were moderate. They were .60 for reading, .70 for mathematics, and .50 for spelling.

TABLE 2

Schematic of Student Assignment to Experimental and Control Conditions

For Each Type of Training with GRA Subtest Scores in Parentheses

Student	Mathematics		Reading		Spelling	
A	Experimental	(3.1)	Experimental	(2.3)	Control	(2.9)
B	Control	(2.9)	Experimental	(1.9)	Experimental	(2.3)
C	Experimental	(2.7)	Control	(1.8)	Control	(2.1)
D	Control	(2.8)	Control	(2.3)	Experimental	(2.8)
E	Experimental	(2.7)	Experimental	(2.6)	Control	(2.9)
F	Control	(2.6)	Control	(2.4)	Experimental	(2.8)
G	Experimental	(2.4)	Control	(2.5)	Experimental	(2.1)
H	Control	(2.6)	Experimental	(2.2)	Control	(2.6)

An examination of the health records of the selected students was made by a pediatric nurse. No history of serious disease or congenital abnormality was found in any of the children. Records were checked especially for rheumatic fever and other disorders which frequently lead to sensory and behavioral problems in youngsters. None of the children had a defect of this type nor did any of them have a hearing loss or suffer from a severe nervous disorder.

Experimental Training Programs

I. Reading:

Four children were intensively trained in the behavioral skills the authors believe are needed for increased proficiency in reading and the development of verbal behavior. The initial plan for the encouragement of verbalization entailed use of a metalic module clown similar to those used in many behavioral studies of language development. It was assumed that the type of children selected for this study would be quite anxious in the presence of the experimenters in the early stages of training and that it might be easier to communicate with them through a loud speaker incorporated into the clown. The clown, in addition, could be used to reinforce verbal and other appropriate behaviors by lighting its nose, wiggling its ears, or by other gestures that children find delightful.

Before spending the considerable time and money to construct this elaborate and tricky apparatus, an attempt was made to replace it with the use of monetary reinforcement. This was carried out in connection with some of the pre-training tests previously described. The student was escorted from his classroom to the training room across the hall by one of the experimenters. A roll of bright new pennies was placed well within the reach of the student as he was told he would receive a penny

reward for each correct answer to a series of questions. Since the first set of items was easy, the student was right and hence reinforced 95% of the time.

This simple technique appears to be excellent for establishing rapport with children for whom social reinforcers are not highly effective. It also seems to be helpful in the control of the behavior of highly emotional students. For the more anxious of the students selected, the concentration required to get the right answer and thus a penny reward easily competes with the emotional responses that frequently dominate their behavior. The shy students quickly adapted to the experimental situation and after two or three days effortlessly started to emit an increasing number of verbal responses. All students by the end of this phase of the program were eager to do an hour or so of intense work per day and were quite vocal about their disappointment when they were not scheduled for a training period.

The crucial factors in the ease and speed with which control of behavior was achieved were (a) the use of material in the initial stages which was difficult enough so as not to appear condescending but easy enough to allow the student many opportunities to be reinforced, (b) keeping the reinforcement constantly in view of the student to increase the student's confidence that appropriate behavior will be reinforced, (c) immedi e reinforcement, (d) the monetary reward helps differentiate the experimenter from adults with whom the students have had punitive associations or who have been capricious about supplying rewards to the child.

The first stage of reading training was designed to increase student competence with a list of 2,021 words drawn from the Thorndike Word List for teachers. These words occur fifty or more times in every million

words of popular print including children's readers. These words should be mastered by third graders before they go on to at least the typical fourth grade level work.

For training purposes the words were presented to the student in a match-to-sample fashion. Two examples appear below:

Example A			Example B		
	it's			author	
its	it is	itself	book	written	writer
0	0	0	0	0	0
1	2	3	1	2	3

If the student correctly matches the meaning of words by pushing Button 2 in Example A and Button 3 in Example B, the exposure apparatus is programmed to go to the next slide. An incorrect response leaves the slide in place. On the initial sequence of the approximately 500 match-to-sample slides, students have been wrong on about 80% of the presentations. Fortunately, the response strength developed in the pre-training period was great enough to sustain their behavior at a high level in this difficult period. During this first sequence the student was informed of and given the rationale for the correct responses after he made a mistake. This explanation was repeated on subsequent sequences whenever the student made the same mistake on two successive exposures of a particular slide.

On the initial sequence a new match-to-sample slide appeared automatically after 15 seconds if the student did not respond at all or made only incorrect responses. On subsequent exposures the presentation time

was reduced to the lowest level at which the student could perform successfully. After four weeks even the weakest student performed reasonably well with exposures as short as five seconds.

This technique of verbal presentation forces the student to discriminate between associative meanings (book-author), synonyms (author-writer), similarities in sound and spelling (it's-its), and other phonetic and morphological associations.

All students were on a continuous reinforcement schedule for the first few training sessions. The difficulty level of several of the word combinations was too high for most of the students, resulting in a desultory and disinterested approach to many of the slides. One student was apparently not reading the words presented on the slides at all. She was content to accept the occasional reward from a fortuitous push of the response buttons.

This situation was corrected by the addition of 30 slides using very simple words and where word response choices were very different in meaning, spelling, and sound. A few slides had to be added to deal with reversal problems such as the confusion of b and d.

The continuous reinforcement schedule worked as follows: (a) if the first response was correct the student received two cents, (b) if the second response was correct the student received one cent, (c) if the second response was incorrect the student was "fined" one penny from a pile of twenty pennies presented at the start of each session. This was done to discourage capricious responding.

All students were gradually shifted to a variable-ratio schedule of reinforcement. On the first shift this consisted of requiring an average of two successive correct responses for a reinforcement. The ratio

finally reached was an average of nine correct responses with two students and an average of seven successively correct responses with the other two students.

Results: Reading Program

Students were presented a total of 2021 words during the reading program. A word was considered learned when the student selected the correct semantic association for it on eight successive trials usually spaced over five days. The number of new words acquired in each five day period for each student is shown in Table 3.

The data in Table 3 clearly shows that all 2021 words were learned by all of the experimental group students. Typically, a student knew ten to fifteen per cent of the programmed words before training. The figures for the pre-training column in Table 3 were extrapolated from a pre-experimental test on fifty representative words. The untrained control group show a slight increase in number of correct semantic associations but their improvement is small indeed when compared to the experimental group.

By the end of the third week all experimental students were learning three hundred words a week or better. The rate of acquisition for the controls is very low, indicating once again that students can go long periods in school without any appreciable advancement in the semantic aspects of reading.

Learning a semantic association does not mean an automatic versatility in the use of words. For example, at the completion of training experimental students were asked to use the words they had learned in an appropriate sentence. They were successful in doing so only about

TABLE 3

Number of Correct Semantic Associations for Experimental and Control Students During Eight Weeks of Training

Experimental Students	Pre-Train. Level	Trials in Blocks of Five Days I	II	III	IV	V	VI	VII	VIII	Total
1	200	28	180	290	325	271	280	298	149	2021
2	290	77	212	312	317	311	300	150	52	2021
3	267	47	205	325	333	278	290	177	99	2021
4	231	55	217	340	346	290	301	151	90	2021

Control Students	Pre-Train. Level	Post-Control Performance
1	247	327
2	286	364
3	211	416
4	288	333

a third of the time. At that, this was a substantial improvement over their pre-training level when they were able to construct the proper sentences less than five per cent of the time. It is clear that match-to-sample semantic skills and sentence construction are, in part, separate abilities but afford some degree of transfer to each other.

Training to increase student tolerance for delays in reinforcement was begun in the middle of the fourth week of the reading program. In the three sessions of that week students were offered a twenty per cent increase in reward (typically, say, from 25 to 30 cents) if they were willing to wait an hour before collecting their daily earnings. All students were willing to accept this long a delay.

During the next week, the experimenter by using a variety of pretexts increased the delay interval up to 24 hours and discontinued the incentive increase in reward. In the sixth week immediate reward was reintroduced. The effect of delay can be seen by examining the data in Table 4. The number of semantic associations acquired in the four day period prior to the onset of delay training is represented by Column A; the number of associations acquired in the eight days during reward delay (divided by two) is shown in Column B; the number of new associations in the four day immediate reward period following delay training is shown in Column C. It can be seen that performance is poorer when reward is delayed and improves when immediate reward is provided. The magnitude of the effect is small but it does occur, without exception, for the entire experimental group.

By the start of the sixth week all students were on a high variable ratio schedule of reinforcement. At this point it was explained to half of the experimental students that the money had run

TABLE 4

Number of Correct Semantic Associations in Periods Before, During, and After Delay of Reward

	A	B	C
Students	Before Delay	During Delay	Post Delay
1	240	221	234
2	237	232	240
3	268	224	242
4	288	240	251

out and they would have to continue in the experiment on the basis of their desire to learn words. The other half of the group continued to receive monetary reinforcement. Praise was the replacement for monetary reward and was administered on a variable ratio schedule. In the 7th week students still on monetary reward were shifted to praise. The students previously shifted to praise were returned to a monetary reward schedule.

The data in Table 5 show the effect of the shift from the monetary to a social reinforcer. Students 2 and 3 monetarily reinforced in week five and socially reinforced in week six show a slight performance change, one increasing the other declining. The changes between the sixth and seventh weeks were difficult to interpret because type of reinforcement was confounded by a tendency for the more difficult words to pile up in the last two weeks of training. Nevertheless, it can be said there is no consistent decline in performance related to the use of praise instead of money.

In summary, then, it took about forty hours to teach students upward of 1800 semantic associations. Monetary rewards were very helpful in the early stages of training but were readily replaced by praise in the later stages. Rewards work better if they are immediate but delays, in this situation, did not produce devastating performance decrements. Students become faster and faster at matching-to-sample, tolerate higher and higher reinforcement ratios, and maintain a high rate of response acquisition.

For most of the time during training students were enthusiastic, alert, and persistent. None of the discipline problems, easy distractibility, and other difficulties encountered by their teachers were present during the reading sessions.

TABLE 5

Relative Performances of Students While Reinforced by Money and Praise

Student	Fifth Week	Sixth Week		Seventh Week	
	Number Correct	Type of Reward	Number Correct	Type of Reward	Number Correct
1	271	Money	280	Praise	298
2	311	Praise	300	Money	150
3	278	Praise	290	Money	177
4	290	Money	301	Praise	151

The effect of the reading program on classroom performance was also assessed. These data will be described after the discussion of the immediate results of the mathematics and spelling programs.

II. Mathematics

Prior to the onset of the formal training period in mathematics students were presented a series of problems in symbolic logic and simple arithmetic operations. Of particular concern in this pre-training was a test of the widely held view that the introduction of difficult mathematical problems leads to emotional responses that compete with successful work in this area. To evaluate this theory on the type of arithmetic material programmed for the students in this study, the following small-scale experiment was conducted. The four students assigned to the experimental condition in arithmetic were told to complete a number series similar to those below.

Type Of Series						
A	1	2	3	4	5	____
	10	11	12	13	14	____
	2	4	6	8	10	____
	5	10	15	20	25	____
B	1	2	4	8	16	____
	64	32	16	8	4	____
	1	5	2	6	3	____
	1	5	2	7	3	____

All four students successfully completed the 32 items presented them on the first trial that were of the type in Series A and none of them could handle (on the first trial) the 32 items like those in Series B. The total number of Series B problems each student got right was tabulated and the four students arranged into matched pairs on the basis of their total scores. One student in each pair was then administered 64 problems like those in Series B. The same problems were presented daily for five successive sessions. The other student in each pair was also given 64 problems on the same schedule. These 64 problems, however, were a randomized mixture of 32 Series A and 32 Series B type problems. All students were informed of correct answers and given the correct answer (and its rationale) when they made a mistake. A ten-cent non-contingent reward was given after each trial.

At the completion of training a new set of Series B type problems was presented once to all four students and the number correct tabulated. The results are shown in the table below:

TABLE 6

Number of Correct Responses as a Function of Type of Series

Training Series	Number Correct
Type B Items	40
Type A and B Items	47

It is clear that the combination of Type A and B training items had a salutary effect on learning. The students trained on Type B items alone, despite the fact they received twice as much practice on this type of item,

do less well when tested on this sort of item. A reasonable conclusion is that the aversive effects of getting so many items wrong produces emotional responses that nullify the greater amount of practice.

All of the material presented was in the form of match-to-sample algorithms. Three examples are shown below:

$3 \times 7 = \underline{?}$			$3 \times \underline{?} = 21$			$\underline{?} \times 7 = 21$		
21	17	10	3	7	8	5	4	3
0	0	0	0	0	0	0	0	0

This particular type of arithmetic problem was emphasized for the following reasons: (a) it easily incorporates the basic operations of addition, division, multiplication, and subtraction; (b) it is a type of mathematical problem third grade teachers find extremely difficult to get across to students; (c) it is a computational operation teachers felt had to be speeded up for the student to progress in mathematics.

With the same apparatus used for verbal presentations it is possible to run through over 200 algorithm slides in less than half an hour. Students were initially reinforced with a penny for every correct response (only one response per slide was permitted). Before the end of the first training day, they were all shifted from a continuous to a variable-ratio schedule of reinforcement. It is widely held that a variable-ratio schedule enhances stimulus control. The observations of the experimenters working with the mathematics students confirms this point in that students do seem to pay greater attention on this kind of schedule. All students reached a schedule where they received a penny reward for an average of ten correct responses.

Along with the manipulation of the reward schedule, the speed of presentation was manipulated. Early in training it became apparent that algorithms could be presented at a much faster rate than verbal material. Some students reduced their required exposure time as much as ten seconds in a single week. The minimum exposure time of two seconds was achieved by all students.

Results: Mathematics Program

Training in mathematics proceeded at a faster rate than expected. The original 2000 problems constructed for the experiment had to be increased to 4000 to keep students busy for a full eight weeks. Students were presented one hundred problems a day. The mean number of trials required by students to reach a criterion of 95% correct answers when the exposure speed was five seconds or less is shown in Table 7. It can be seen that performance improves steadily for all the experimental students up to the third or fourth week and then levels off for the remainder of the training period. The pre-training performance varied over a wide range, but all students reach a performance asymptote of two-three trials to criterion in roughly the same number of training sessions. The improvement in computational speed and accuracy can only be attributed to the training program since the performance of the control students hardly changes at all over the eight week period of the experiment.

Starting in the fifth week, students two and three (Table 7) were shifted to the social reinforcer (praise) on the same high variable ratio schedule that prevailed at the end of the preceding week. Students one and four continued to receive monetary reinforcement until the beginning of the seventh week when they were shifted to social reinforcement. It is apparent that these changes in type of reinforcement had no effect on student proficiency.

TABLE 7

Mean Number of Trials Required by Experimental and Control Students To Reach Speed and Accuracy of Response Criteria

Experimental Students	Pre-Train. Level	I	II	III	IV	V	VI	VII	VIII
1	9	7	5	3	3	2	3	2	3
2	7	7	6	2	4	3	2	3	3
3	12	12	9	5	3	3	3	3	3
4	6	3	2	2	2	2	2	2	2

Control Students	Pre-Train. Level	Post-Control Performance
1	8	9
2	10	7
3	12	10
4	5	5

Students adapt readily to the mathematics program and reach highly proficient levels of performance quickly. There is high degree of transfer from the problems programmed to problems of a similar nature. Undoubtedly more complex material could have been included in the curriculum without disturbing the high performance levels achieved.

III. Spelling Program

Several types of automated spelling programs were tried out before the onset of formal training. The first required the student to select the correctly spelled form of a word from two deceptive misspellings. In a second approach the test word was exposed on a screen and then slowly faded out. The student was then asked to spell the word aloud. Both of these techniques proved to be very time consuming and produced a slow rate of learning.

A variation on these two methods was most efficient when used by a group of students prior to this experiment. A test word was presented visually with key letters left out. At the same time the word was pronounced (on synchronized tape) to be sure the student was responding to the word the experimenter intended. The omissions entailed letter combinations comprising common types of spelling errors of third graders.

Below the test word were three choices to which the student could respond by pushing the appropriate button. Three examples appear below and others can be seen in the appendices.

althou__			rec__ve			mon__		
hg	gh	ew	ei	ie	ee	ie	ee	ey

This procedure was amenable to the same type of reinforcement schedules and speeding up of response rate as was the case in verbal

learning and mathematics. It had the distinct advantage of focusing on the parts of a word that involved most of the spelling errors, thereby reducing a considerable amount of redundancy in training.

In the formal eight-week program, students were trained one hour per day, five days a week. The same 2021 Thorndike-Lorge words used for semantic associations were used for spelling.

As will be seen in the results section that follows, spelling is not an easy skill to teach or automate. To keep experimental conditions as clear as possible, a test of the effect of delay in reinforcement was not incorporated into the spelling program.

Results: Spelling Program

Spelling was the most difficult area to teach by the methods employed in this study. None of the experimental students learned to spell all 2021 words correctly. Table 8 shows the number of new words correctly spelled each week. All of the experimental students improve markedly over the eight week training period while the control students do not change appreciably. Toward the end of training, experimental students are learning to spell new words at a positively accelerated rate.

At the start of the fifth week, students 1 and 2 were put on a variable ratio schedule of social reinforcement. Students 3 and 4 were retrained on monetary reinforcement until week seven when money was replaced by praise for the last two weeks of training. Examination of the data in Table 8 clearly indicates that these changes in reinforcement had a negligible effect on spelling proficiency.

It was not possible to reduce stimulus exposure rates as low for spelling as it was for mathematics and reading. In the eighth week of training even the most proficient speller needed a four-second test

TABLE 8

Mean Number of New Words Correctly Spelled at Various Stages of Training
By Experimental and Control Students

Experimental Students	Pre-Train. Level	Trials in Blocks of Five Days I	II	III	IV	V	VI	VII	VIII	Total
1	141	50	100	125	142	137	179	183	190	1247
2	291	72	114	137	167	172	211	223	239	1626
3	341	83	127	153	179	189	251	260	274	1857
4	189	67	109	117	147	141	191	210	217	1388

Control Students	Pre-Train. Level	Post-Control Performance
1	225	247
2	271	339
3	160	210
4	250	240

stimulus presentation to do successful work. The comparable exposure time for reading and mathematics was around two seconds.

Training in spelling was made more arduous by the difficulty in synchronizing vocal and visual presentation of test words. Current work in the author's laboratory has solved this problem but at the time the experimental training was conducted it caused many frustrating interruptions.

Despite the many limitations on the training procedure used, it did substantially improve the performance of four very poor spellers. Future modifications in apparati and techniques should make acquisition of all 2021 words in eight weeks attainable for all but the very poorest of students.

IV. Somatic Measures

Three somatic measures were taken over the eight week training period. These were hours of sleep per night, food consumption, and oral temperature. Data on the first two was obtained in interviews spaced an average of three days apart. To reduce the probability of students preparing answers in advance of the interview, no information was given as to when a particular individual would be questioned. Despite these precautions it was difficult to eliminate a tendency for students to exaggerate the number of hours they had slept and the quality of meals they received at home (in a few cases rather direct observations by social workers conflicted with student reports).

Oral temperature was taken before each experimental session by a pediatric nurse who also served as an experimenter. Amazingly, there were almost no absences during the training period so that forty or close to forty temperature measurements were made on each of the eight students in the study.

After each interview a rating was given to the quality of a child's diet for that day. The rating was on a five point scale, a "one" indicating a close proximity to the dietary requirements for third graders specified by the Evansville Public School System and a "five" indicating a total deviation from these requirements.

Pearson correlations were run between diet ratings and the major performance measures for the three training areas. None of these correlations were significantly different from zero at the .05 level of confidence. The same lack of significant results held for the correlations between hours of sleep and the academic measures.

The only somatic measure with any relation to academic performance was oral temperature. The effect of temperature was small but quite consistent. The relative rank of an experimental student at the end of a particular training session usually declined if his temperature was over 99 degrees Fahrenheit.

A perhaps more striking finding was that the lower two experimental students in each training area had a higher mean temperature over the forty training sessions than did the upper two experimental students. This may mean that a student's academic performance is adversely affected by a chronic infection of insufficient magnitude to merit medical attention or to keep the child away from school.

V. Results--Grades, Ratings, Retention Tests

The extent of transfer from the experimental training program to the classroom was assessed in three ways, (a) grade changes in the school period during and after training, (b) ratings by a teacher of the relative performance of experimental and control group students in reading,

spelling, and arithmetic, (c) test of the amount of training material retained over retention intervals of one day and four months.

Grades for all students over their entire third grade year are shown in Table 9. Experimental training was begun toward the end of grading period IV and was completed near the end of grading period V. Periods I, II, and III preceded experimentation, and Period VI followed it.

It is clear that the training program did not produce a multitude of A (scores 5 and 6) students. However, careful inspection of grading periods V and VI indicate grades in these post-training periods are higher than in the pre-experimental periods. The increments are larger and more consistent for the experimental students than the controls.

The largest improvement is in spelling grades. This is probably due to the similarity between the experimental training in spelling and the spelling tests used to establish grades. Further, spelling is an unidimensional skill whereas reading and mathematics represent a multiplicity of abilities.

The classroom teacher, six weeks after the experimental training, was asked to rank her eight students in reading, spelling, and mathematics. Since all students were participants in the experiment, there was no direct way for her to know which students were in the experimental and control groups. The possibility of subtle cues operating to influence the teacher's judgments in a biased way cannot be ruled out entirely.

The results of these rankings are shown in Table 10. Generally, experimental students rank higher than the controls. A Mann-Whitney U test run on these rankings indicated that the difference between the experimental and control group rankings is significant only in the case of spelling. This is attributable to the same factors affecting differences in grades.

TABLE 9

Experimental and Control Student Grades for Periods Preceding and Following Training

Subject Area	Training Condition	Grading Periods I	II	III	IV	V	VI
Reading	Experimental	2	2	3	3	3	3
	Experimental	3	3	2	2	3	3
	Experimental	1	1	1	1	2	3
	Experimental	2	1	2	2	3	3
	Control	2	3	3	2	2	2
	Control	1	1	1	2	1	2
	Control	3	2	3	2	3	2
	Control	2	2	2	2	2	2
Mathematics	Experimental	1	1	1	1	2	2
	Experimental	1	1	2	2	3	3
	Experimental	2	3	2	2	2	2
	Experimental	3	3	3	3	3	3
	Control	1	1	2	1	2	1
	Control	2	3	2	2	2	2
	Control	3	1	2	3	3	3
	Control	3	2	2	2	2	1
Spelling	Experimental	-*	-	3	3	3	4
	Experimental	-	-	1	1	1	3
	Experimental	-	-	2	2	3	3
	Experimental	-	-	1	2	2	3
	Control	-	-	3	3	3	3
	Control	-	-	1	2	1	1
	Control	-	-	2	2	2	2
	Control	-	-	3	1	2	2

Grade Code: 1 = 70-74, 2 = 75-79, 3 = 80-84, 4 = 85-89, 5 = 90-94, 6 = 95-100.

*Spelling was not tested the first two periods.

TABLE 10

Ranking of Experimental and Control Students
In Reading, Spelling, and Arithmetic

Rank	Reading	Arithmetic	Spelling
1	C	E	E
2	E	C	E
3	E	E	E
4	C	C	C
5	E	E	E
6	E	C	C
7	C	E	C
8	C	C	C
Mann-Whitney U	6	6	1*

*Significant at the .014 level of confidence

Retention tests were conducted at intervals of one day and four months after the completion of the eight week training program. For spelling and semantic associations, one hundred of the 2021 training words were randomly selected, presented for a single test trial, and the per cent correct computed. For mathematics, a random selection of 200 problems (of the 4000) was used for the retention test.

The results of these tests are shown in Table 11. It may be noted that in arithmetic and the semantic association categories, retention is not one hundred per cent even for the one day retention interval. The one day level for spelling is confounded by the fact that acquisition in this category had not reached one hundred per cent at the end of training.

Retention over the four month interval was best for mathematics. This may be an intrinsic characteristic of mathematics or the result of a greater amount of practice in this subject during the retention interval.

When compared to the retention levels usually found for academic material, the findings of this phase are encouraging. While retention is by no means perfect, it is sufficiently high to insure that training can have substantial effects at least four months beyond the time of acquisition. While not affording a formal experimental test, these results probably reflect the superiority of intermittent schedules of reinforcement in establishing behavior resistant to extinction.

Summary
Conclusions and Implications

Several improvements in the technology of education are suggested by the results of this study. First of all, it is clear that a considerable modification in the academic performance of elementary school children can be achieved with a simple apparatus, over a reasonable period of time, and without highly sophisticated personnel. The

TABLE 11

Retention of Semantic Associations, Spelling, and Arithmetic One Day And Four Months After the Completion of Training

Student	Retention Interval	Per Cent of Semantic Associations Recalled	Per Cent Arithmetic Problems Correct	Per Cent Spelling Correct
1	One Day	90	97	77
	Four Months	80	93	62
2	One Day	92	95	78
	Four Months	78	88	71
3	One Day	94	90	81
	Four Months	86	82	66
4	One Day	95	95	67
	Four Months	73	95	58

match-to-sample programming increased the vocabulary of four failing students by close to 2000 words, improved the speed and accuracy of many of their computational skills, and raised the spelling proficiency of those trained by a substantial amount. While the transfer from the experimental training employed to the classroom cannot be demonstrated in an unequivocal way, several measures strongly indicate improvement in school traceable to specific experimental conditions.

After the novelty of working on a programmed apparatus has worn off, some motivational replacement is needed to sustain student performance. Frequently the students who are poorest academically and need this type of training the most are unresponsive to such conventional motivating-reward techniques as praise and knowledge of results. This makes all types of instruction, and perhaps automated methods more than others, difficult with this category of student. The effectiveness of monetary reinforcers in this study, therefore, appears to the author to be a most important finding. For as little as a dollar per week, students called lazy by both parents and teachers were willing to work very hard. Further, by the use of appropriate reinforcement schedules it is possible to demand more and more work for less and less money. Finally, monetary reward can be phased out as training progresses and replaced by a social reinforcement, typically used in the classroom, such as praise.

To a trained observer of this type of experimental procedure it is clear that the teacher-experimenter becomes a discriminative stimulus for a group of emotional responses highly compatible with learning. Students were enthusiastic about participation in the study and vocal about their disappointment when they did not get to take part on a given occasion. These reactions are in direct contrast to the sullen defiance or enervating anxiety so common when poor students are asked to struggle

with material they find difficult. Students were eager to perform well and regarded the experimenter's approval as being of some importance. The use of monetary rewards (or an equivalent), under response contingent conditions, can be highly recommended.

It is a maxim of linear programming to break difficult material into component steps that the student can more readily handle. It may also be advisable to include test questions on previously mastered related work along with new study matter. The reinforcement obtained in correctly responding to the known material helps maintain attentiveness and reduces the emotional responses emenating from the inevitable failures associated with new and difficult subject matter.

Pwehaps the biggest advantage of the program investigated is the number and variety of skills that can be taught at the same time. Speed, comprehension, alertness, and to a lesser degree persistence all seem to improve together. The apparatus and method can accommodate all of the basic subject areas taught in the elementary grades.

Teachers and researchers who may be interested in trying out this remedial program may find the synopsis of its crucial components helpful.

Duration:
- a. 40-60 minutes per day
- b. six-ten weeks

Apparati:
- a. Visual Test Module, match-to-sample program
- b. 2021 2" x 2" slides of semantic associations presented in match-to-sample form using those words that occur 50 or more times in every million words on the Thorndike list
- c. 2021 match-to-sample spelling slides using the same words
- d. 4000 match-to-sample arithmetic algorithms

Types of Reinforcement:
- a. knowledge of results
- b. praise
- c. money, toys

Reinforcement Schedules:

a. begin with continuous reinforcement
b. shift to higher and higher variable ratio schedule as fast as performance allows

Stimulus Time Exposure:

a. Reading - begin at 12 seconds, reduce to two seconds as performance permits
b. Mathematics - begin at 8 seconds, reduce to two seconds as rapidly as you can
c. Spelling - begin at 12 seconds, reduce to about four seconds but at a lower rate than for reading or mathematics

It is hoped that there will be an expanding technology in this type of remedial program. The program suggested in this report is based on solid experimental evidence. Recently researchers in the author's laboratory have been conducting a cross-validation study on a diverse sample of 23 public school youngsters. While the length of training was abbreviated compared to that for the original sample, the results of the two studies are very much in line. This, of course, increases the validity of the recommendations made on the preceding pages.

The outcome of some phases of the study were disappointing. Performance decrements resulting from delays in reinforcement were difficult to eliminate. Monetary incentives were of some help, but fall considerably short of complete success. When reward was delayed there was a noticeable loss of attentiveness that increased as a training session progressed. Further analyses of the harmful effects of reinforcement delay and techniques for their elimination are badly needed.

The relation between somatic measures and academic skill was not very pronounced. There is some suggestion that an elevated temperature is associated with performance decrements. However, the effect is small and subject to more than one interpretation. Perhaps with more objective measures of diet, hours of sleep, and other aspects of hygiene, a better analysis of physical factors in learning can be made.

Further studies in this area should consider training students on more complex material and to utilize more sophisticated forms of problem solving. A study is beginning now in the author's laboratory on ways to encourage third graders to use mediational responses as a short cut to certain types of problem solutions. The addition of this sort of cognitive skill might very well assist the student in making the jump from remedial training to the classroom.

APPENDIX A

I. Pre-training Mathematics Sequence

1 2 3 4 5 6 _____

3 4 5 6 7 8 _____

10 11 12 13 14 15 _____

7 8 9 10 11 12 _____

2 4 6 8 10 12 _____

4 8 12 16 20 24 _____

5 10 15 20 25 30 _____

15 20 25 30 35 40 _____

3 4 3 4 3 4 _____

4 6 4 6 4 6 _____

2 2 3 3 4 4 _____

6 6 5 5 4 4 _____

3 6 9 12 15 18 _____

4 7 10 13 16 19 _____

5 4 5 4 5 4 _____

6 5 6 5 6 5 _____

1 2 3 1 2 3 _____

3 4 5 3 4 5 _____

18 21 24 27 30 33 _____

12 15 18 21 24 27 _____

1 3 5 7 9 11 _____

5 7 9 11 13 15 _____

6 5 4 6 5 4 _____

8 7 6 8 7 6 _____

3 6 9 12 15 18 _____

1 4 7 10 13 _____

2 4 8 _____

1 2 4 8 _____

64 32 16 8 4 _____

16 8 4 2 4 8 _____

13 11 9 7 5 3 _____

48 24 12 6 12 24 _____

1 5 2 6 3 7 4 _____

2 6 3 7 4 8 5 _____

1 5 2 7 3 9 4 _____

1 4 2 6 3 8 4 _____

1 3 2 5 3 7 4 _____

32 16 8 4 _____

4 8 16 _____

32 16 8 4 8 16 _____

13 11 9 7 5 3 _____

24 12 6 3 6 12 _____

2 5 3 6 4 7 5 _____

3 6 4 7 5 8 6 _____

3 8 4 9 5 10 6 _____

1 2 3 4 5 4 3 _____

1 6 2 8 3 10 4 _____

1 7 2 9 3 11 4 _____

1 7 2 10 3 13 4 _____

9 8 7 6 7 8 9 _____

APPENDIX A

II. Pre-training Mathematics Sequence

1 2 3 4 5 6 _____

3 4 5 6 7 8 _____

10 11 12 13 14 15 _____

7 8 9 10 11 12 _____

2 4 6 8 10 12 _____

4 8 12 16 20 24 _____

5 10 15 20 20 25 _____

15 20 25 30 35 40 _____

3 4 3 4 3 4 _____

4 6 4 6 4 6 _____

2 2 3 3 4 4 _____

6 6 5 5 4 4 _____

3 6 9 12 15 18 _____

4 7 10 13 16 19 _____

5 4 5 4 5 4 _____

6 5 6 5 6 5 _____

1 2 3 1 2 3 _____

3 4 5 3 4 5 _____

18 21 24 27 30 33 _____

12 15 18 21 24 27 _____

1 3 5 7 9 11 _____

5 7 9 11 13 15 _____

1 2 3 4 5 6 _____

6 5 4 6 5 4 _____

5 10 15 20 25 30 _____

8 7 6 8 7 6 _____

4 5 6 7 8 9 _____

1 4 7 10 13 _____

15 14 13 12 11 10 _____

2 4 8 _____

5 10 15 20 25 30 _____

64 32 16 8 4 2 _____

2 4 6 8 10 12 _____

13 12 11 10 9 8 _____

48 24 12 6 12 24 _____

5 4 5 4 5 4 _____

1 5 2 6 3 7 4 _____

3 6 9 12 15 18 21 _____

1 2 3 4 5 6 _____

1 5 2 7 3 9 4 _____

5 10 15 20 25 _____

32 16 8 4 _____

14 13 12 11 10 9 _____

4 8 16 _____

13 11 9 7 5 _____

2 5 3 6 4 7 5 _____

1 2 3 4 5 6 7 _____

1 2 3 4 5 4 3 _____

4 4 5 5 6 6 7 _____

1 7 2 9 3 11 4 _____

APPENDIX A

III. Verbal Meanings

ago	pair	long	lose	save	two
_____	_____	_____	_____	_____	_____
agree	paper	cut	doll	saw	think same
_____	_____	_____	_____	_____	_____
air	Paris	plane	city	say	path
_____	_____	_____	_____	_____	_____
all	part	picture	portion	scene	everything
_____	_____	_____	_____	_____	_____
allow	pass	ocean	go by	sea	let
_____	_____	_____	_____	_____	_____
almost	passage	teacher	nearly	school	hall
_____	_____	_____	_____	_____	_____
alone	past	winter	together	season	present
_____	_____	_____	_____	_____	_____
along	pay	with	chair	seat	money
_____	_____	_____	_____	_____	_____
already	peace	first	by now	second	war
_____	_____	_____	_____	_____	_____
also	people	seen	furthermore	see	crowd
_____	_____	_____	_____	_____	_____
although	perhaps	look for	even though	seek	maybe
_____	_____	_____	_____	_____	_____
always	period	appear	of time	seem	never
_____	_____	_____	_____	_____	_____
am	person	buy	somebody	sell	is
_____	_____	_____	_____	_____	_____
America	pick	receive	New York	send	choose
_____	_____	_____	_____	_____	_____

APPENDIX B

I. A list of words with a semantic association index of between one and two. These are words missed less than 10 per cent of the time on the first three match-to-sample trials.

able	another	black	caught	doctor
about	April	boat	bless	drag
above	army	boil	cause	drop
accompany	around	border	cent	during
across	art	boy	certain	earth
act	Atlantic	brave	change	eat
addition	August	break	chief	engine
address	aunt	bright	choose	enter
afraid	automobile	bring	Christmas	entire
again	baby	brook	coffee	entrance
ahead	bad	brush	conversation	establish
aid	bark	build	crowd	exist
alarm	battle	but	curious	fear
all	beautiful	call	daily	fate
allow	begin	calm	danger	fashion
alone	behind	can	dash	fault
always	beneath	cannot	desert	favor
animal	bent	cup	display	
announce	big	case	double	

II. A list of words with a semantic association index of between two and three. These are words missed about 50 per cent of the time on the first three match-to-sample trials.

activity	attack	bought	character	cry
add	author	bound	cheap	cut
admire	avenue	bow	circumstance	decide
admit	average	box	claim	dozen
affair	awful	brain	clean	delight
against	band	branch	close	depend
agree	bar	brief	cloth	describe
aim	bear	British	coast	destroy
already	beat	broad	collect	develop
anger	beauty	broken	college	difficult
appear	begun	bury	committee	discover
apply	behold	busy	company	distant
approach	change	cabin	companion	doesn't
arm	besides	California	compel	due
arose	best	campaign	complete	education
arrive	beyond	car	conduct	effort
article	bill	cast	contain	elect
ask	block	catch	continue	employ
asleep	blow	advice	copy	even
assume	Bob	amount	cost	examine
assure	body	appeal	count	
ate	bore	cell	couple	

APPENDIX B

III. A list of words with a semantic association index of between three and four. These are words missed more than 90 per cent of the time on the first three match-to-sample trials.

accept	character	development
accident	bond	difference
actual	burden	direct
advance	cease	effect
attempt	check	enough
attend	clothe	equal
attention	combine	everyone
authority	commerce	evidence
avoid	crop	fact
base	decline	fair
benefit	determine	family

APPENDIX C

A Sample of Programmed Spelling Words

1. ass_me: u, o, i
2. as_ure: e, h, s
3. attem_t: p, t, h
4. av_nue: i, a, e
5. awf_l: a, u, e
6. ben_fit: i, e, u
7. brig_t: h, e, t
8. b_sy: i, e, u
9. b__ld: ui, iu, uo
10. bord_r: a, i, e
11. bou_ht: a, g, u
12. br__f: ei, ie, ee
13. bru_h: c, s, t
14. b_sy: i, u, e
15. cab_n: i, e, o
16. amo__t: un, on, en
17. acros_: c, t, s
18. Ameri_a: c, s, k
19. aro_nd: w, o, u
20. atten__on: ti, ch, sh
21. ca_se: w, u, a
22. Chris_mas: t, s, h
23. clot_: h, e, t
24. coll_ge: e, a, i
25. cr_: i, e, y
26. de_ide: s, c, z
27. e_rth: a, u. i
28. educa__on: ti, sh, ch
29. ent_r: a, e, i
30. eq_al: w, a, u
31. e_t: a, i, e
32. fa_t: c, k, a
33. f_rst: i, u, e
34. f_rm: i, u, e
35. fre_h: s, c, t
36. freq_ently: u, w, e
37. fr__ndly: ei, ie, ee
38. go_d: w, u, l
39. g__ss: ue, eu, iu
40. hand__: el, le, il
41. hi_h: e, g, w
42. hol_: i, r, y
43. h_rt: e, u, i
44. clos_: s, e, t
45. _ourney: g, j, l
46. mi_ht: g, e, a
47. less_n: o, i, a
48. menti__: en, on, in
49. meth_d: o, i, e
50. n_rrow: e, a, o
51. pa_se: u, w, s
52. sho_er: w, u, o
53. pup__: il, el, le
54. pri_e: s, z, e
55. re_dy: a, e, d
56. remar_: c, h, k
57. s__d: ea, ai, ie
58. scat_er: a, e, t
59. ser_ous: a, e, i
60. simp__: il, el, le
61. a_cident: s, k, c
62. affa__: er, re, ir
63. anot_er: u, e, h
64. ans_er: e, u, w
65. atten_: s, t, d
66. A_gust: a, w, u
67. bea_ty: w, u, h
68. bod_: e, i, y
69. bra__: ne, in, hn
70. c__ght: au, ou, oa
71. __rtain: ci, se, ce
72. ch__p: ae, ie, ea
73. ch__f: ei, ee, ie
74. condu_t: c, k, e
75. co_nt: u, h, w
76. do__n: se, zi, ze
77. d_ring: e, i, u
78. en_ine: c, j, g
79. ev_n: i, o, e
80. for_st: a, e, i
81. g_ri: e, i, u
82. g_ard: w, u, o
83. lang_age: w, u, i
84. lo_er: h, u, w
85. ma_l: y, i, e
86. ma__e: yb, bb, ib
87. nati_n: e, o, u
88. offi__r: ci, se, ce
89. oth_r: i, o, e
90. pri_t: s, n, m
91. r__ch: ee, ie, ea
92. reca_l: u, l, w
93. act__l: oo, ua, ue
94. afra_d: e, i, y
95. alwa_s: e, y, i
96. ba_e: z, s, c
97. allo_: h, w, e
98. besid__: ez, se, es
99. bloc_: h, c, k
100. c_lm: a, i, o
101. arti__e: cl, sl, kl
102. bro__: wd, ad, de
103. c_mpany: u, o, i
104. contin__: uu, ew, ue
105. curi_us: a, o, i
106. d__ble: uo, ou, ow
107. evid_nce: e, a, i
108. f__: ew, ue, eu
109. gent__: le, il, el
110. harb_r: a, u. o